CLAIMS

What is claimed is:

1. A method, comprising:

using an optical probe beam with a substantially uniform wavefront to illuminate a surface under measurement to produce a reflected probe beam with a reflected wavefront that carries distortions caused by an illuminated area on the surface;

directing the reflected probe beam through an optical shearing interferometer device to obtain an optical interference pattern between the reflected wavefront and another replica of the reflected wavefront that is spatially shifted by a shearing distance;

adjusting a phase shift between the reflected wavefront and the replica of the reflected wavefront to obtain a plurality of phase-shifted interference patterns of different phase shifts from the optical shearing interferometer; and

processing the interference patterns to obtain information on surface slopes across the illuminated area in the surface under measurement.

2. The method as in claim 1, further comprising using a coherent gradient sensing (CGS) system with diffraction gratings as the optical shearing interferometer.

3. The method as in claim 1, further comprising using a radial shear interferometer as the optical shearing interferometer.

4. The method as in claim 1, further comprising using a bi-lateral shearing interferometer with a wedge plate as the optical shearing interferometer.

5. The method as in claim 1, further comprising using prisms in the optical shearing interferometer to produce the optical interference pattern between the reflected wavefront and the replica of the reflected wavefront.

6. The method as in claim 1, further comprising adjusting the phase shift to produce phase shifts of 0, 90, 180, 270, and 360 degrees.

7. The method as in claim 1, further comprising applying an algorithm in processing of the interference patterns of different phase shifts to compute the phase information to extract information on surface slopes in the illuminated area on the surface under measurement.

8. The method as in claim 7, further comprising applying a minimum discontinuity (MDF) algorithm within the algorithm.

9. The method as in claim 7, further comprising applying a preconditioned conjugate gradient (PCG) algorithm within the algorithm.

10. The method as in claim 7, further comprising applying a branch cut minimization algorithm within the algorithm.

11. The method as in claim 7, further comprising applying a tiled modulation guided algorithm within the algorithm.

12. The method as in claim 7, further comprising statistically fitting a surface polynomial to measured surface slopes.

13. The method as in claim 12, further comprising using a Zernicke polynomial as the surface polynomial.

14. The method as in claim 12, further comprising applying integration and differentiation procedures to a statistic surface fit of the measured surface slopes.

15. The method as in claim 1, further comprising using the surface slopes to obtain curvature information of the illuminated area.

16. The method as in claim 1, further comprising using the surface slopes to obtain information on stress in the illuminated area.

17. The method as in claim 1, further comprising applying a phase extraction algorithm in processing the interference patterns.

18. The method as n claim 18, wherein the phase extraction algorithm includes one selected from Bucket A, Bucket B, and Bucket C algorithms.

19. The method as in claim 12, further comprising using a Lengendre polynomial as the surface polynomial.

20. A system, comprising:

a collimated radiation source to produce a collimated probe beam onto a surface under measurement

an optical shearing interferometer device positioned to receive the optical probe beam reflected from the surface and to

cause an optical interference between a reflected wavefront of the optical probe beam and another replica of the reflected wavefront that is spatially shifted by a shearing distance, wherein the optical shearing interferometer is operable to adjust a phase shift between the reflected wavefront and the replica of the reflected wavefront to obtain a plurality of phase-shifted interference patterns of different phase shifts;

an imaging device to capture the interference patterns produced by the optical shearing interferometer; and

a processing device to process the interference patterns captured by the imaging device to extract information on surface slopes across the illuminated area in the surface under measurement.

21. The system as in claim 20, wherein the optical shearing interferometer comprises a coherent gradient sensing (CGS) system with diffraction gratings.

22. The system as in claim 20, wherein the optical shearing interferometer comprises a radial shear interferometer.

23. The system as in claim 20, wherein the optical shearing interferometer comprises a bi-lateral shearing interferometer with a wedge plate.

24. The system as in claim 20, wherein the optical shearing interferometer comprise prisms which operate to produce the optical interference pattern between the reflected wavefront and the replica of the reflected wavefront.

25. The system as in claim 20, wherein the optical shearing interferometer adjusts the phase shift to produce phase shifts of 0, 90, 180, 270, and 360 degrees.

26. The system as in claim 20, wherein the processing device is programmed to unwrap the phase information in the interference patterns of different phase shifts to extract information on surface slopes in the illuminated area on the surface under measurement.

27. The system as in claim 26, wherein the processing device is programmed with a minimum discontinuity (MDF) algorithm to unwrap the phase information.

28. The system as in claim 26, wherein the processing device is programmed with a preconditioned conjugate gradient (PCG) algorithm to unwrap the phase information.

29. The system as in claim 26, wherein the processing device is programmed with a branch cut minimization algorithm to unwrap the phase information.

30. The system as in claim 26, wherein the processing device is programmed with a tiled modulation guided algorithm to unwrap the phase information.

31. The system as in claim 26, wherein the processing device is operable to statistically fit a surface polynomial to measured surface slopes.

32. The system as in claim 31, wherein the processing device is programmed to apply a Zernicke polynomial for the statistic fitting.

33. The system as in claim 31, wherein the processing device is operable to apply integration and differentiation procedures to a statistic surface fit of the measured surface slopes.

34. The system as in claim 20, wherein the processing device is operable to use the surface slopes to obtain curvature information of the illuminated area.

35. The system as in claim 20, wherein the processing device is operable to use the surface slopes to obtain information on stress in the illuminated area.

36. The system as in claim 31, wherein the processing device is programmed to apply a Lengendre polynomial for the statistic fitting.

37. The system as in claim 20, wherein the processing device is programmed to apply a phase extraction algorithm in processing the interference patterns.

38. The system as n claim 37, wherein the phase extraction algorithm includes one selected from Bucket A, Bucket B, and Bucket C algorithms.

39. A method, comprising:

using support members to contact a backside surface of a wafer to hold the wafer, wherein the wafer is fabricated with patterns on a front surface opposite to the backside surface;

illuminating the backside surface with a probe beam to produce a reflected probe beam with a reflected wavefront that

carries distortions caused by an illuminated area on the backside surface;

producing an optical interference pattern with the reflected probe beam, wherein the interference pattern comprises discontinuities due to presence of support members on the backside surface;

applying an interpolation algorithm in processing the optical interference pattern to interpolate interference fringes caused by the backside surface across regions with the discontinuities to obtain interference pattern features within the illuminated area that are caused solely by the backside surface; and

processing the interpolated interference pattern from the backside surface to obtain surface slopes of corresponding positions on the front surface of the wafer.

40. The method as in claim 39, further comprising using a linear interpolation algorithm to interpolate the interference fringes.

41. The method as in claim 39, further comprising using a Spline interpolation algorithm to interpolate the interference fringes.

42. The method as in claim 39, further comprising checking interpolated fringes according to spatial frequency content and consistency of other fringes in the interference pattern.

43. The method as in claim 39, further comprising:

using the support members to change an angular orientation of the wafer at least once to obtain at least one another reflected optical probe beam and another optical interference pattern;

applying the interpolation algorithm in processing the other optical interference pattern to interpolate interference fringes caused by the backside surface across regions with the discontinuities to obtain interference pattern features within the illuminated area that are caused solely by the backside surface;

processing the interpolated the other interference pattern from the backside surface to obtain surface slopes of corresponding positions on the front surface of the wafer;

comparing interference information between the interference patterns obtained at different angular orientations to find missing data; and

filling missing data at a location in one interference pattern by using data at said location in another interference pattern obtained at a different angular orientation.

44. The method as in claim 39, further comprising arranging the support members in a non-symmetric way to support the backside surface of the wafer.

45. The method as in claim 39, further comprising using a shearing interferometer to process the reflected probe beam to produce the optical interference pattern.

46. The method as in claim 39, further comprising using a non-shearing interferometer to process the reflected probe beam to produce the optical interference pattern.

47. The method as in claim 46, further comprising:

directing a second probe beam to the patterned front surface to produce a second reflected probe beam by optical reflection at the patterned front surface;

using a shearing interferometer to process the second reflected probe beam to produce a second optical interference pattern; and

extracting surface information on the patterned front surface from the optical interference pattern and the second optical interference pattern.

48. A method, comprising:

using support members to contact a backside surface of a wafer to hold the wafer, wherein the wafer is fabricated with patterns on a front surface opposite to the backside surface;

illuminating the backside surface with a probe beam to produce a reflected probe beam with a reflected wavefront that carries distortions caused by an illuminated area on the back surface;

producing an optical interference pattern with the reflected probe beam, wherein the interference pattern comprises discontinuities due to presence of support members on the backside surface;

processing the interference pattern from the backside surface to obtain surface slopes of corresponding positions on the front surface of the wafer;

changing an angular orientation of the wafer on the support members at least once to obtain at least one another reflected optical probe beam from the same optical probe beam and thus another optical interference pattern;

processing the other interference pattern from the backside surface to obtain surface slopes of corresponding positions on the front surface of the wafer;

comparing surface slopes obtained from different interference patterns at different angular orientations of the wafer; and

filling missing data found at a location in one interference pattern by data at said location in another interference pattern obtained at a different angular orientation.

49. The method as in claim 48, further comprising arranging the support members in a non-symmetric way to support the backside surface of the wafer.

50. A method, comprising:

using support members made of a material transparent to light at a probe wavelength to contact a backside surface of a wafer to hold the wafer, wherein the wafer is fabricated with patterns on a front surface opposite to the backside surface;

illuminating the backside surface with a probe beam at the probe wavelength to produce a reflected probe beam with a reflected wavefront that carries distortions caused by an illuminated area on the back surface;

producing an optical interference pattern with the reflected probe beam; and

processing the interference pattern from the backside surface to obtain surface slopes of corresponding positions on the front surface of the wafer.

51. A method, comprising:

illuminating an optical probe beam with a substantially uniform wavefront onto a surface under measurement to produce a new optical beam with a distorted wavefront caused by the surface;

directing the new optical beam through an optical shearing interferometer to obtain an optical interference pattern between the distorted wavefront and another replica of the distorted wavefront that is spatially shifted by a shearing distance;

adjusting the shearing distance to obtain optical interference patterns at different shearing distances; and

processing the interference patterns at different shearing distances to extract information on the surface under measurement.

52. The method as in claim 51, further comprising using optical reflection of the surface to produce the new optical beam.

53. The method as in claim 51, further comprising using optical transmission of the surface to produce the new optical beam.

54. The method as in claim 51, further comprising using a coherent gradient sensing system (CGS) interferometer as the optical interferometer.

55. The method as in claim 51, further comprising:

subtracting two interference patterns with two different shearing distances to produce a differentiate interference pattern that corresponds to a new shearing distance equal to a difference between the two different shearing distances.

56. The method as in claim 55, further comprising selecting the new shearing distance to be a beam size of the optical probe beam.

57. A method, comprising:

performing chemical mechanical polishing (CMP) on a wafer surface of a wafer;

during the CMP, illuminating an optical probe beam with a substantially uniform wavefront onto the wafer surface to

produce a new optical beam with a distorted wavefront caused by the wafer surface;

directing the new optical beam through an optical shearing interferometer to obtain an optical interference pattern between the distorted wavefront and another replica of the distorted wavefront that is spatially shifted by a shearing distance;

adjusting the shearing distance to obtain optical interference patterns at different shearing distances;

processing the interference patterns at different shearing distances to extract information of surface nanotopography on the wafer surface; and

using the extracted information to control operating parameters in the CMP.

58. The method as in claim 57, further comprising modifying a slurry flow rate of the CMP according to the extracted information.

59. The method as in claim 57, further comprising modifying a polishing pad pressure of the CMP according to the extracted information.

60. The method as in claim 57, further comprising modifying a polishing pad velocity of the CMP according to the extracted information.

61. The method as in claim 57, further comprising modifying a slurry composition of the CMP according to the extracted information.

62. The method as in claim 57, further comprising modifying a polishing pad stiffness according to the extracted information.